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**UNITED STATES PATENT APPLICATION**

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for

**APPARATUS, SYSTEM, AND METHOD FOR SWITCHING DATA  
LIBRARY MANAGERS**

# APPARATUS, SYSTEM AND METHOD FOR SWITCHING DATA LIBRARY MANAGERS

## BACKGROUND OF THE INVENTION

### 1. The Field of the Invention

The invention relates to devices, methods, and systems for managing data libraries. Specifically, the invention relates to devices, methods, and systems for switching library managers in a data library system.

### 2. The Relevant Art

Systems of mainframe computers or servers frequently maintain large data libraries. Data libraries typically contain many storage devices including hard disk drives, tape drives, and optical storage drives. Computers retrieve data from and store data to the storage devices in the data library through a device controller.

A computer, usually a host computer, issues a data transaction command to the device controller. The device controller employs one or more library managers to coordinate accessing data in the data library. The library manager schedules and executes the data transaction command on the storage devices.

A system administrator often must switch library managers from a first library manager to a second library manager. Switching library managers typically requires that the storage devices in the data library be forced offline and that the data transaction commands awaiting execution be canceled. The first library manager is suspended and the second library manager is activated. Storage devices must be varied online or restarted before the second library manager can resume receiving and executing data transaction requests. Library managers may also be switched by taking the data library offline and allowing the

1 data transaction commands awaiting execution to complete. The data library must be varied  
2 online to resume standard data library operation.

3 Figure 1 is a block diagram illustrating a representative data library system 100 of the  
4 current technology. The system 100 includes one or more host computers 105, one or more  
5 library managers 110, one or more storage devices 115, and a device controller 120. The  
6 system 100 shows the functional elements of a data library.

7 The host computer 105a issues a data transaction command to the device controller  
8 120. The device controller 120 assigns the data transaction command to the first library  
9 manager 110a for data to be retrieved from or saved to the storage device 115. The first  
10 library manager 110a directs a storage device 115 to complete the command. The depicted  
11 data library system 100 also includes a second library manager 110b.

12 A system administrator switches library management functions from the first library  
13 manager 110a to a second library manager 110b. In the depicted system, the system  
14 administrator forces the storage devices 115 offline and suspends the first library manager  
15 110a from accepting data transaction commands. Previously accepted data transaction  
16 commands are lost. The system administrator then activates the second library manager 110b  
17 and varies the storage devices 115 online, allowing the second library manager 110b to  
18 execute data transaction commands.

19 In other systems, the system administrator takes the data library system 100 offline  
20 and allows previously accepted data transaction commands to complete. The system  
21 administrator suspends the first library manager 110a and activates the second library  
22 manager 110b. The data library system 100 is varied online or otherwise placed on-line to  
23 resume data library operations.

24 Figure 2 is a flow chart diagram illustrating a library manager transition method 200  
25 of the current technology. The method 200 includes a force storage device offline step 205, a  
26 notify host step 210, a take library offline step 215, a switch library manager step 220, a vary  
27 storage device step 225, an inform host step 230, and an end step 235.

1 A system administrator activates the method 200. The force storage device offline  
2 step 205 forces the storage devices 115 in the data library system 100 offline. The notify host  
3 step 210 communicates to the host computer 105 that the data library retained by the storage  
4 devices 115 will be unavailable. The take library offline step 215 takes the data library  
5 offline, making the library inaccessible to the host computer 105.

6 The switch library manager step 220 commands the first library manager 110a to  
7 suspend library management functions. The step 220 further directs the second library  
8 manager 110b to activate library management functions. The vary storage device step 225  
9 varies the storage devices 115 online under the management of the second library manager  
10 110b. The inform host step 230 communicates to the host computer 105 that the data library  
11 has resumed accepting data transaction commands. The end step 235 terminates the method  
12 200.

13 Taking storage devices 115 or the data library system 100 offline lengthens the time  
14 required to switch library managers and slows data processing functions. Data Library  
15 functions would be enhanced if library managers could be switched without taking storage  
16 devices 115 or the data library system 100 offline.

17 What is needed is a method for switching library managers while the data library  
18 remains online. What is more particularly needed is a device, method, and system for  
19 switching library managers while maintaining storage devices online.  
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## SUMMARY OF THE INVENTION

The various elements of the present invention have been developed in response to the present state of the art, and in particular, in response to the problems and needs in the art that have not yet been fully solved by currently available methods for transitioning data library managers. Accordingly, the present invention provides an improved method, apparatus, and system for switching library managers in a data library system.

In one aspect of the present invention, an apparatus for switching library managers is presented. The apparatus includes a control module, a communications module, and a timing module. The control module, communications module, and timing module are configured to manage switching library managers for a data library. The data library may reside on one or more storage devices. A library manager accepts data transaction commands and executes the commands using the storage devices. Typically only one library manager is active.

During a library manager transition, library management functions for a data library are switched from a first library manager to a second library manager. The communications module receives a directive for the library manager transition. The control module receives and sends communications through the communications module.

The control module is also configured to direct the first library manager to reject new data transaction commands. The storage devices of the data library remain online and may continue to complete commands. In one embodiment, the first library manager continues to execute accepted data transaction commands. The first library manager may also continue to accept select data transaction command types.

The control module is configured to suspend the management functions of the first library manager. In one embodiment, the first library manager's library management functions are suspended when accepted data transaction commands are executed. In an alternate embodiment, the library management functions are suspended prior to the execution of all accepted data transaction commands.

1           The control module activates the library management functions of the second  
2 library manager. The second library manager then accepts and executes data transaction  
3 commands. The storage devices remain online and capable of completing data  
4 transaction commands throughout the library manager transition. The second library  
5 manager may execute data transaction commands without waiting for storage devices to  
6 be varied online and resume completing commands.

7           In one embodiment, the timing module receives a directive to limit the duration of  
8 the library manager transition. The directive is received through the communications  
9 module. The timing module may initiate a timeout period and notify the control module  
10 of the end of the timeout period. Responsive to the timing module, the control module  
11 may terminate execution of data transaction commands by the first library manager and  
12 activate the library management functions of the second library manager.

13           In another aspect of the present invention, a method for switching library managers is  
14 presented. The method rejects new data transaction commands for retrieving data from or  
15 storing data to a data library during a library manager transition. The storage devices of the  
16 data library are maintained online and able to complete previously accepted data transaction  
17 commands. The method suspends the library management functions of a first library  
18 manager and activates the library management functions of a second library manager.

19           Various elements of the present invention are combined into a system for switching  
20 library managers. The system includes a first library manager performing library  
21 management functions. The first library manager executes a data transaction command,  
22 directing the storage devices of a data library to retrieve or store data. A second library  
23 manager may also reside on the system, but not actively manage the data library.

24           A system administrator directs a transition manager module to switch library  
25 management functions from the first library manager to a second library manager. In one  
26 embodiment, the transition manager module resides in a device controller. In an alternate  
27 embodiment, the transition manger module is distributed throughout the library management

1 system. The transition module may notify a host computer that a library manager transition  
2 has commenced and that no new data transaction commands will be accepted. The first  
3 library manager may process previously accepted data transaction commands during the  
4 library manager transition.

5 The transition manager module suspends the library management functions of the  
6 first library manager and activates the management functions of a second library manager.  
7 The second library manager accepts and executes data transaction commands. The transition  
8 manager module informs the host computer that the library manager transition is complete  
9 and that the second library manager will accept new data transaction commands.

10 In one embodiment, the present invention facilitates the switching of library managers  
11 in a data library while maintaining storage devices online responsive to data transaction  
12 commands. In another embodiment, the present invention also supports the orderly  
13 execution of previously accepted data transaction commands during a library manager  
14 transition. The various elements and aspects of the present invention may provide a rapid,  
15 efficient means of switching library managers, decreasing data processing delays due to idle  
16 systems during the library manager transition. These and other features and advantages of  
17 the present invention will become more fully apparent from the following description and  
18 appended claims, or may be learned by the practice of the invention as set forth hereinafter.  
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## **BRIEF DESCRIPTION OF THE DRAWINGS**

In order that the manner in which the advantages of the invention are obtained will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Figure 1 is a block diagram illustrating a data library system of the current technology;

Figure 2 is a flow chart illustrating a library manager transition method of the current technology;

Figure 3 is a block diagram illustrating one embodiment of a library management system of the present invention;

Figure 4 is a block diagram illustrating one embodiment of a transition manager module of the present invention;

Figure 5 is a flow chart illustrating one embodiment of a library manager transition method of the present invention; and

Figure 6 is a flow chart illustrating a further embodiment of a library manager transition method of the present invention.



## DETAILED DESCRIPTION OF THE INVENTION

Many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, modules may be implemented in software for execution by various types of processors. An identified module of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions, which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module. For example, a module of executable code could be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices.

Modules may also be implemented in hardware as electronic circuits comprising custom VLSI circuitry, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays, programmable array logic, programmable logic devices or the like.

Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

Figure 3 is a block diagram illustrating one embodiment of a library management system 300 of the present invention. The system 300 includes one or more host computers 105, a transition manager module 320, a device controller 120, one or more library managers 110, and one or more storage devices 115. The transition manager module 320 may be located within the device controller 120 or may be implemented independent thereof. The

1 library management system 300 is configured to retrieve and store data. The system 300 is  
2 also configured to conduct a library manager transition.

3 In operation, the library manager 110 accepts data transaction commands to retrieve  
4 data from or store data to the storage devices 115. The library manager 110 may execute data  
5 transaction commands immediately or store the data transaction commands for later  
6 execution. The storage devices 115 complete data transaction commands, retrieving and  
7 storing data.

8 The transition manager module 320 receives a directive from the system  
9 administrator to switch library management functions from a first library manager 110a to a  
10 second library manager 110b. The transition manager module 320 suspends the first library  
11 manager 110a from accepting new data transaction commands, but maintains the storage  
12 devices 115 online. Storage devices 115 may continue to complete data transaction  
13 commands executed by the first library manger 110a. In one embodiment, the transition  
14 manager module 320 directs the first library manager 110a to execute previously accepted  
15 data transaction commands in the command queue. In an alternate embodiment, the  
16 transition manager module 320 transfers previously accepted data transaction commands  
17 from the first library manger 100a to the second library manager 110b.

18 The transition manager module 320 suspends the library management functions of  
19 the first library manager 110a and activates the library management functions of the  
20 second library manager 110b. The storage devices 115 are capable of completing data  
21 transaction commands from the second library manager 110b.

22 The system 300 allows library managers 110 to be switched without forcing  
23 storage devices 115 offline. In addition, the system 300 may resume data library  
24 operations without varying storage devices 115 online. The system 300 further supports  
25 completing previously accepted data transaction commands during the library manager  
26 transition.

1           Figure 4 is a block diagram illustrating one embodiment of a transition manager  
2 module 320 of the present invention. The module 320 includes a control module 405, a  
3 communications module 410, and a timing module 415. The transition manager module  
4 320 manages a library manager transition in the library management system 300.

5           The communications module 410 receives a directive from the system  
6 administrator to switch library managers from a first library manager 110a to a second  
7 library manager 110b. The communications module 410 forwards the directive to the  
8 control module 405. In one embodiment, the control module 405 directs the first library  
9 manager 110a to stop accepting new data transaction commands. The control module  
10 405 may also direct the host computer 105 to stop issuing data transaction commands. In  
11 one embodiment, the control module 405 issues directives through the communications  
12 module 410.

13           In one embodiment, the control module 405 directs the first library manager 110a  
14 to execute previously accepted data transaction commands. The control module 405 may  
15 also terminate the execution of previously accepted data transaction commands.

16           In an alternate embodiment, communications module 410 receives a timeout  
17 directive from the system administrator. The communications module 410 communicates  
18 the timeout directive to the timing module 415 and the control module 405. The timing  
19 module 415 may begin timing a timeout period in response to a timeout directive. In one  
20 embodiment, the timeout period is specified by the system administrator. The timeout  
21 period may also be predetermined. The timing module 415 notifies the control module  
22 405 when the timeout period completes. The control module 405 may the execution of  
23 previously accepted data transaction commands by the first library manager 110a in  
24 response to notification that the timeout period has been completed.

25           The control module 405 directs the first library manager 110a to suspend library  
26 management functions and further directs the second library manager 110b to activate  
27 library management functions. In one embodiment, the control manager 405 informs the

1 host computer 105 that the host computer 105 may resume issuing data transaction  
2 commands.

3 The transition manager module 320 switches library managers 110 without  
4 forcing storage devices offline. Additionally, the transition manager module 320 may  
5 allow the first library manager 110a to complete previously accepted data transaction  
6 commands. The transition manager module 320 further activates the library management  
7 functions of the second library manager 110b with the storage devices 115 remaining  
8 capable of completing commands, allowing the library management system 300 to rapidly  
9 resume operation.

10 Figure 5 is a flow chart illustrating one embodiment of a library manager  
11 transition method of the present invention. The method 500 is illustrated herein being  
12 conducted using the system 300 of Figures 3 and 4, but may also be conducted  
13 independently thereof. The method 500 includes a notify host step 510, a reject new data  
14 commands step 515, a process data commands step 520, a suspend first library manager  
15 step 525, an activate second library manager step 530, an inform host step 535, and an  
16 end step 540. The method 500 transitions library management functions in the library  
17 management system 300 from the first library manager 110a to the second library  
18 manager 110b. Although for purposes of clarity the steps of the method 500 are depicted  
19 in a certain sequential order, execution within an actual system may be conducted in  
20 parallel and not necessarily in the depicted order.

21 The notify host step 510 communicates to the host computer 105 that the data  
22 library will be unavailable, and that new data transaction commands will not be accepted.  
23 The reject new data commands step 515 rejects new data transaction commands directing  
24 access to data in the storage devices 115. The process data commands step 520 executes  
25 previously accepted data transaction commands. In one embodiment, accepted data  
26 transaction commands are stored in a command queue.

1 The suspend first library manager step 525 suspends the first library manager 110a  
2 from performing library management functions. The activate second library manager step  
3 530 activates the second library manager 110b performing library management functions.  
4 The inform host step 535 communicates to the host computer 105 that the second library  
5 manager 110b is ready to accept and execute data transaction commands. The end step  
6 540 terminates the method 500.

7 The library manager transition method 500 switches library management  
8 functions without taking storage devices 115 or data library system 100 offline. The  
9 method 500 also allows previously accepted data transaction commands to be completed  
10 during the library manager transition.

11 Figure 6 is a flow chart illustrating a further embodiment of a library manager  
12 transition method of the present invention. The method 600 is illustrated herein being  
13 conducted using the system 300 of Figures 3 and 4, but may also be conducted  
14 independently thereof. The method 600 includes a notify host step 510, a reject new data  
15 commands step 515, a process data commands step 520, a suspend first library manager  
16 step 525, an activate second library manager step 530, an inform host step 535, a  
17 commands executed test 605, a cancel transition test 610, a timeout specified test 620, a  
18 timeout expired test 625, an accept new data commands step 630, an inform host of  
19 cancellation step 635, and one or more end steps 640. The library manager transition  
20 method 600 switches library managers 110 while allowing a system administrator  
21 additional transition options. Although for purposes of clarity the steps of the method  
22 600 are depicted in a certain sequential order, execution within an actual system may be  
23 conducted in parallel and not necessarily in the depicted order.

24 Steps 510, 515, 520, 525, 530, and 535 perform the same functions as described in  
25 the library manager transition method 500 of Figure 5. The commands executed test 605  
26 determines if the first library manager 110a has executed all previously accepted data  
27 transaction commands. If the first library manager 110a has executed all accepted data

1 transaction commands, the method 600 loops to the suspend first library manager step  
2 525.

3 If the first library manager 110a has not executed all of the data transaction  
4 commands in the command queue, the method 600 proceeds to the cancel transition test  
5 610. The cancel transition test 610 determines if a system administrator has directed the  
6 cancellation of the library manager transition. If the system administrator has directed the  
7 cancellation of the library manager transition, the method 600 proceeds to the accept new  
8 data commands step 630. The accept new data commands step 630 directs the first  
9 library manager 110a to accept data transaction commands. The inform host of  
10 cancellation step 635 communicates to the host computer 105 that the library manager  
11 transition is canceled, and that the first library manager 110a will accept data transaction  
12 commands. The method 600 terminates with the end step 640b.

13 If the system administrator has not directed the cancellation of the library manager  
14 transition, the method 600 proceeds from the cancel transition test 610 to the timeout  
15 specified test 620. The timeout specified test 620 determines if the system administrator  
16 specified a timeout period for the library manager transition. If no timeout period was  
17 specified, the method 600 loops to the process data commands step 520. If a timeout  
18 period was specified, the method 600 proceeds to the timeout expired test 625.

19 The timeout expired test 625 determines if the time interval expended by the first  
20 library manager 110a processing previously accepted data transaction commands exceeds  
21 the timeout period specified by the system administrator. If the time interval expended by  
22 the first library manager 110a has not exceeded the timeout period, the method 600 loops  
23 to the process data commands step 520. If the time interval has exceeded the specified  
24 timeout period, the method 600 loops to the suspend first library manager step 525. The  
25 end step 630a terminates the method 600.

26 The library manager transition method 600 allows the system administrator to  
27 terminate the execution of previously accepted data transaction commands during the

1 library manager transition. The method 600 further allows the system administrator to  
2 limit the execution of previously accepted data transaction commands to within a  
3 specified timeout period.

4 In one embodiment, the present invention facilitates the switching of library managers  
5 in a data library while maintaining storage devices online responsive to data transaction  
6 commands. In another embodiment, the present invention also supports the orderly  
7 execution of accepted data transaction commands during a library manager transition. The  
8 various elements and aspects of the present invention may provide a rapid, efficient means of  
9 switching library managers, decreasing data processing delays due to idle systems during the  
10 library manager transition. The present invention may be embodied in other specific forms  
11 without departing from its spirit or essential characteristics. The described embodiments are  
12 to be considered in all respects only as illustrative and not restrictive. The scope of the  
13 invention is, therefore, indicated by the appended claims rather than by the foregoing  
14 description. All changes which come within the meaning and range of equivalency of the  
15 claims are to be embraced within their scope.

16 What is claimed is:  
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